Subterranean Biology 34: 109–119 (2020)
doi: 10.3897/subtbiol.34.50673
http://subtbiol.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Subterranean Biology
Published by The International Society for Subterranean Biology

Acheroxenylla (Collembola, Hypogastruridae), first record from the Americas with description of a new species from a Peruvian cave

José G. Palacios-Vargas[1]

1 *Laboratorio de Ecología y Sistemática de Microartrópodos, Depto. Ecología y Recursos Naturales, Facultad de Ciencias, UNAM, Coyoacán 04510, México*

Corresponding author: José G. Palacios-Vargas (troglolaphysa@hotmail.com)

Academic editor: O. T. Moldovan | Received 31 January 2020 | Accepted 29 April 2020 | Published 27 May 2020

http://zoobank.org/52274932-8D7D-4DAC-94D8-9DF52EB60ACA

Citation: Palacios-Vargas JG (2020) *Acheroxenylla* (Collembola, Hypogastruridae), first record from the Americas with description of a new species from a Peruvian cave. Subterranean Biology 34: 109–119. https://doi.org/10.3897/subtbiol.34.50673

Abstract

A new diagnosis for *Acheroxenylla* Ellis, 1976 is proposed, based on new characteristics recently discovered in other species of the genus. A new species living on guano from oil bird guacharo is described and illustrated and its Barcode Index Number (BIN) from BOLD System is given. A key for the identification of the four known species is also included.

Keywords

Xenyllian group, cueva de Samuel, chaetotaxy, troglomorphy

Introduction

Ellis (1976) created the genus *Acheroxenylla* as closely related to *Xenylla*. Since they share the absence of postantennal organ, the number and location of Ant. IV sensilla, the number of tenent hairs on tibiotarsi, the absence of unguiculus, and the general

Copyright *José G. Palacios-Vargas*. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

appearance of the chaetotaxy. He argued that most *Xenylla* species have 5 + 5 eyes or at least 4 + 4. So, he created a new genus for one species from Crete, Greece, which most remarkable characteristic is the presence of only two eyes per side and a complete lack of furcula. However, even in *Xenylla* the reduction or absence of a furcula is rare, there is a gradation between fully developed furcula (with manubrium, dens and mucro) and completely lacking, as seen from *X. boerneri* Axelson, 1905 to *X. acauda* Gisin, 1947. Later Fjellberg (1992) found two species of *Acheroxenylla* in Canary Islands, one of them, *A. furcata* with a reduced furcula and, thus, the author increased the knowledge and characters of the genus.

After Thibaud et al. (2004), *Acheroxenylla* has the type I of chaetotaxy in the Hypogastruridae with short setae (mesosetae), sometimes more or less ciliated, and with longer and fine sensory setae; and these authors have called it type "Xenyllian" because all of them lack a postantennal organ. There are 8 genera in this type: *Acherongia*, *Acherontides*, *Acherontiella*, *Acheroxenylla*, *Paraxenylla*, *Pseudacherontides*, *Thibaudylla* and *Xenylla*, with almost 200 species of the 715 known in the family Hypogastruridae (Bellinger et al. 2019). Around 130 Collembola species in 12 families have been cited from Perú (Bocanegra 2013), two of them members of the Xenyllian group but Peruvian members of this group living in caves have never been studied.

Material and methods

In a recent expedition organized by Josiane Lips to collect cave fauna, several samples were collected in six caves from Rioja Province (northern Perú). They were processed by Berlese-Tullgren, hand collected and kept in alcohol. All of them were preserved in ethanol 96% at the Department of Entomology, Museo de Historia Natural, Universidad Mayor de San Marcos, Perú. Later the specimens of Collembola were sent to the Laboratorio de Ecología y Sistemática de Microartrópodos, Faculty of Sciences, Universidad Nacional Autónoma de México for study.

Among the Collembola, some specimens of *Acheroxenylla* were found. Five were preserved for molecular study and six were prepared in Hoyer's solution. Later, they were studied under a contrast phase microscope Carl Zeiss mod. 465270-9906 and drawn with the aid of a camera lucida.

For the molecular study each of the five specimens were photographed and sent for sequencing with the standard COI–5P marker ("DNA barcode", Ratnasingham & Hebert, 2013) at the Canadian Centre for DNA Barcoding.

Abbreviations used in this paper are: Ant = antennal segment; Abd = abdominal segment; hr = anal valve setae; PAO = postantennal organ; Sgd = dorsal guard sensillum; Sgv = ventral guard sensillum; Th = thoracic segment; a = anterior row of setae; m = median row of setae; m' = microsensillum; or = apical organ; p = posterior row of setae; S = sensillum; ss = sensorial seta; Tita = tibiotarsus.

Results

Class Collembola Lubbock, 1870
Order Poduromorpha Börner, 1913
Family Hypogastruridae Börner, 1906

Acheroxenylla Ellis, 1976 new modified diagnosis

Notes. Small Hypogastruridae (from 0.5 to 1.3 mm). Setae not differentiated in macrosetae, only with smooth or slightly barbulate mesosetae and longer sensory setae. They are usually white, with dark or black color only under each eye, with possible bluish gray pigmentation all over the body. Antennae cylindrical about the same length as the head, with a simple or trilobed retractile papilla; Ant IV with a dorso-external microsensillum, a subapical sensorial organ and 4 cylindrical or oval sensilla: 3 external and one internal. Ant. III organ with 2 microsensilla hidden by or not by a tegumentary fold and framed by 2 longer guard sensilla. Ocelli 2 + 2 (sometimes 1 + 1). Postantennal organ always lacking. Head chaetotaxy with setae a0 and d0; five pairs of dorsal cephalic setae; and two or three subdorsal pairs. Claws without teeth and empodium. Th I with 3 + 3 setae; Th II–III with 4 + 4 setae on row a, 3 + 3 on m row and 4 + 4 on row p. Or a: 3 + 3 and 2 + 2; m: 3 + 3 (m2 and m3 absent) and 1 + 1 lateral; p: 4 + 4 or 5 + 5; two pairs of ss at position m6 and p4. Without lateral microsensillum on Th II. Abd I–III with 2 rows of setae (a and p): 5 + 5 or 6 + 6; one pair of ss at p5; Abd IV with 3 rows of setae (a: 3 + 3 or 4 + 4; m: 2 + 2 (with or without m1 or m4); p: 4 + 4 or 5 + 5; one pair of ss at position p5). Abd V with 2 rows (a and p: 2 + 2 or 3 + 3) one pair of ss at position p3. Each tibiotarsus with 2 or 1 tenent hairs. Ventral tube with 4 + 4 setae. Retinaculum either with 2 or 3 teeth on each ramus or complete absent. Furcula present, reduced or absent. Manubrium, when present, with 2 or 3 pairs of setae, dens if present short or long with maximum 2 setae. Mucro absent except one case. Always with 2 very small anal spines on papillae of the same size.

Type species. *Acheroxenylla cretensis* Ellis, 1976

Key to species

1 Furcula and retinaculum absent **2**

– Furcula and retinaculum well developed or reduced, but always present **3**

2 2 + 2 eyes, occasionally with small pigment spots; p3 on Abd. IV present..... ..... ***A. cretensis* Ellis, 1976 (Greece: Creta Island)**

– 2 + 2 eyes, always with blue pigment spots; p3 on Abd. IV absent..... ***A. canariensis* Fjellberg, 1992 (Spain: Canary Islands: El Hierro, Gomera, La Palma, Tenerife, Gran Canaria, Lanzarote)**

3 Retinaculum with 3 + 3 teeth. Furcula well developed with mucro, long dens with 2 long setae...***A. lipsae* sp. nov. (Perú: Province Rioja, Cueva de Samuel)**

– Retinaculum with 2 + 2 teeth. Furcula very reduced without mucro, short dens with 2 tiny setae.....***A. furcata* Fjellberg, 1992 (Spain: Canary Islands: La Gomera, Tenerife, Gran Canaria, Fuerteventura, Lanzarote)**

***Acheroxenylla lipsae* sp. nov.**

http://zoobank.org/3EF8532D-FD4F-4DB2-A547-5C60CE1107C5

Figures 1–12

Description. ***Holotype female*** (number FC-UNAM 22501) and one paratype female (numbers FC– UNAM 22502) are kept at Dept. Entomology; Museo de Historia Natural, Universidad Mayor de San Marcos, Perú; two paratypes females one male and one juvenile (numbers FC–UNAM 22500, 22503 to 22325) are kept at Mexican Collembola collection at Facultad de Ciencias, UNAM.

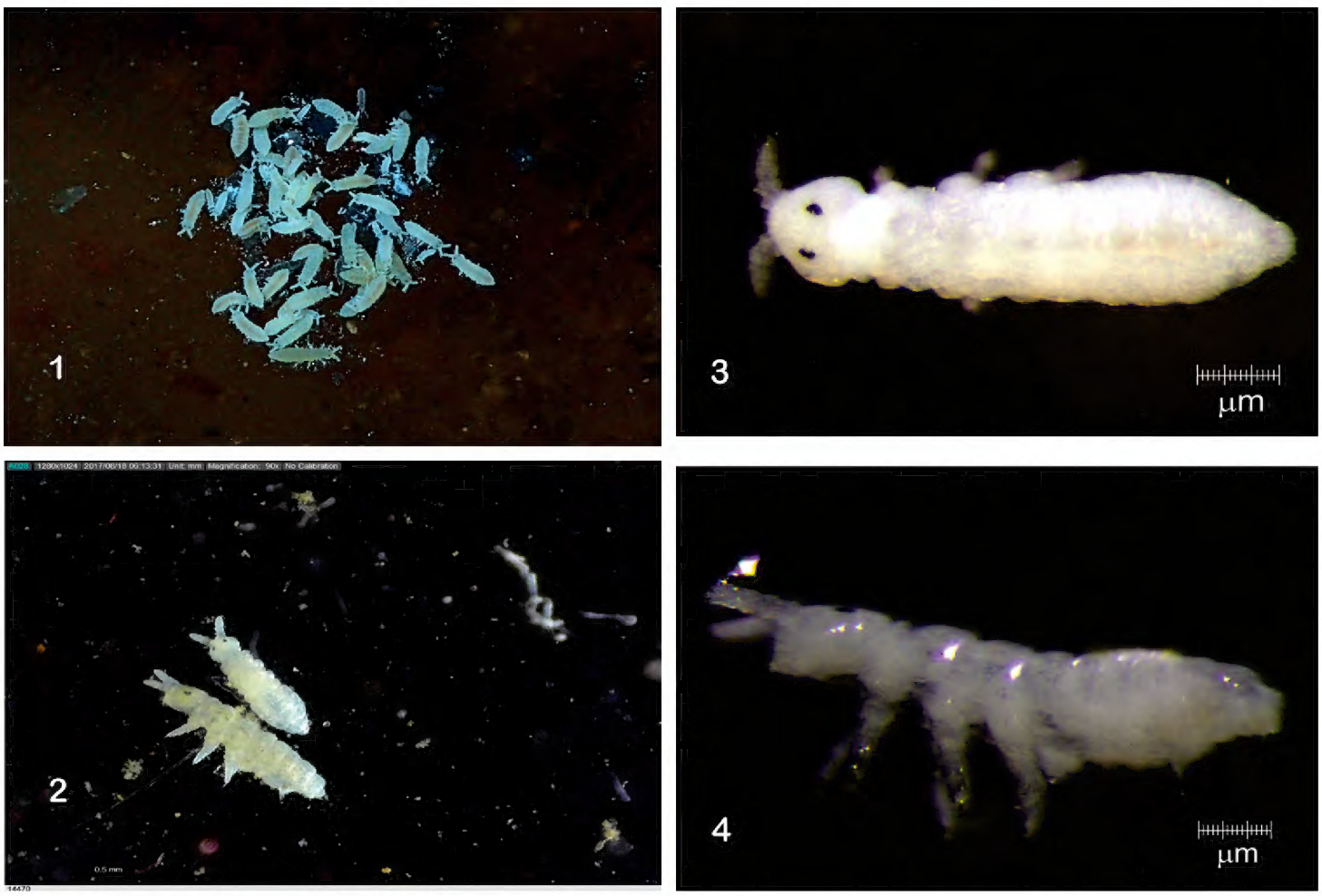
Type locality. Perú: Region San Martín; Province Rioja, Cueva de Samuel (6°06'92"S, 77°31'58"W) 1,720 m a.s.l. About 5.5 Km North-West of town Naciente de Rio Negro. 16-viii-2017, sample 14470, J. Lips col.

Diagnosis. *Acheroxenylla lipsae* sp. nov. is characterized by the presence of a well-developed furcula with mucro, long dente with two long dental setae each, three manubrial setae and a retinaculum with three teeth. Tibiotarsi are longer than in other species known.

Description. ***Body length*** (average of 7 specimens) = 1.25 mm. Setae not differentiated in macro and microsetae, all smooth and sharp mesosetae about 11 µm with small barbulations. Sensorial setae longer than regular setae, about 30 µm. Sensorial formula as 022/11111. Color, some specimens (Figures 1, 2) with very dark eyespots; others gray with small patches of blue color on body and black eyespots (Figures 3, 4). Cuticular granulation strong, Yossi´s parameter 5 or 6. Ratio of head: antenna = 1:0.8 labrum formula: 2/5,5,4.

Ant I with seven dorsal setae, Ant II with 12 setae. Ant III with 17 setae in two whorls, sense organ with two free club-shaped microsensilla, not covered by tegumentary fold; two short guard sensilla (Sgd and Sgv) of same shape and size, and one ventral microsensillum. No eversible sac between Ant III-IV. Ant IV with four cylindrical sensilla, one dorsal and three latero-external; subapical organite, lateral microsensillum and simple subapical bulb (Figure 5), no sensory file on ventral side. Ratio of Ant I: II; III–IV = 1:1.1; 1.4; 3.8.

Head with typical chaetotaxy for the genus, similar to *Xenylla*, only 3 subdorsal setae, seta c1 and only 1 setae v (v1), and 3 subequal setae in ocular area (Figure 6). 2 + 2 eyes of about equal diameter with very strong granulations of dark pigment. PAO absent. Labium with 4 + 4 setae (one longer than others); 3 pairs of postlabial setae. Mandible with 3–4 apical teeth, and normal molar plate. Maxilla with six lamellae. Th I with 3 + 3 dorsal setae and 1 + 1 lateral on upper subcoxae. Each Th II and III with 3 irregular rows of setae (Figure 8), sensorial setae m6 and p4 as usual.

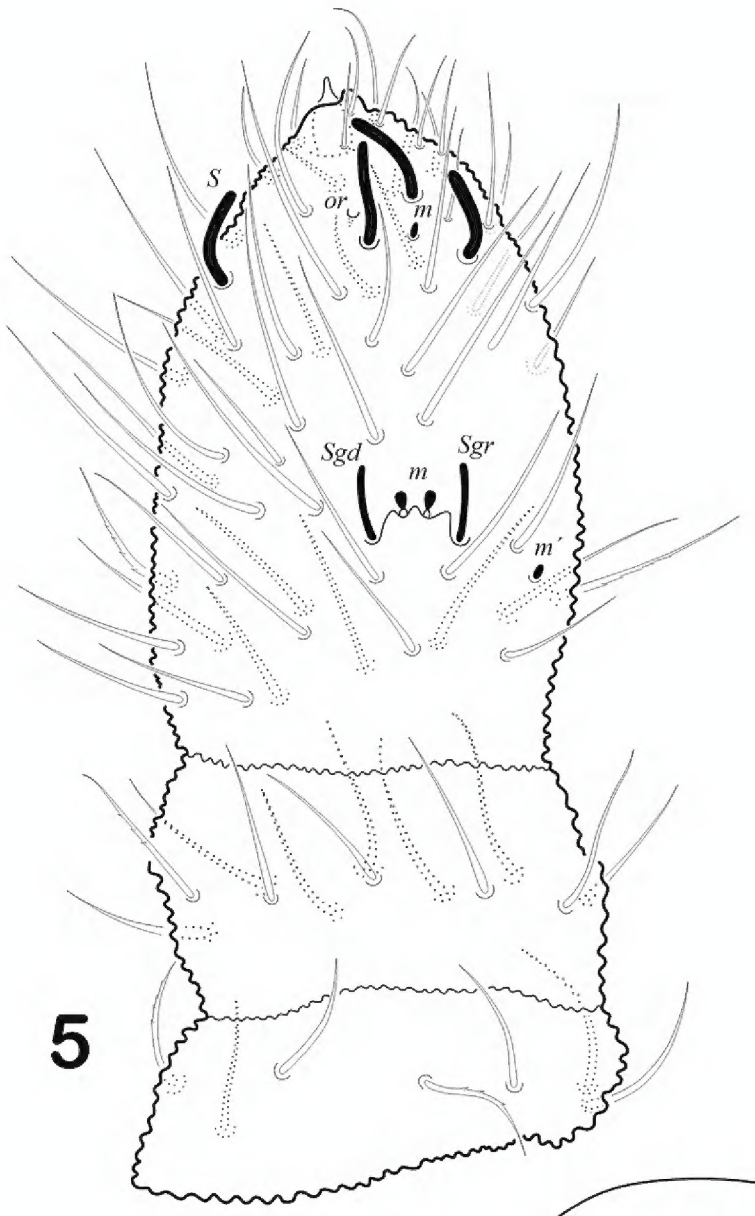


Figures 1–4. 1 *Acheroxenylla lipsae* sp. nov. 1, group of specimens floating on water close to the guano of oil birds **2** two specimens dorsal view just collected in ethanol 96%; photos 1 and 2 by Josiane Lips **3** dorsal view **4** lateral view, photos 3 and 4 by Maira Montejo and Angela Arango, scale in photos 3 and 4 is 150 µm.

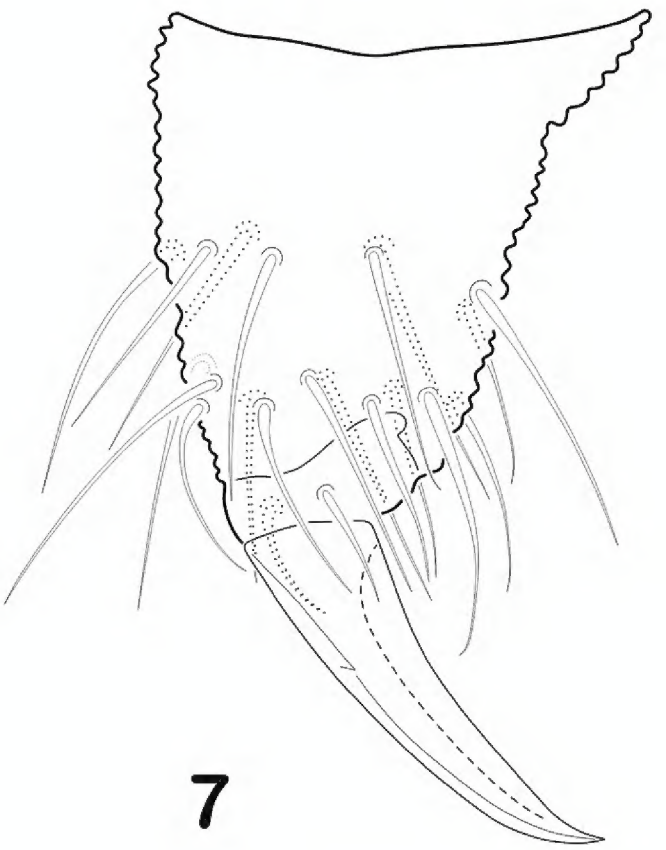
Leg chaetotaxy from I to III: precoxae 0,1,2; coxae 3,6–8,5–8; trochanters 5,5,4; femora 12,11,10 one ventral seta very long, as acuminate tenent hair; Tita 19,19,18 (Figures 7, 9); pretarsi 2,2,2. Two dorsal tenent hairs weakly clavate on dorso-distal whorl on Tita I and II; one on Tita III. Unguis thin, elongated, curving slightly, without any tooth (Figures 7–9). No unguiculus. Ratio Tita/unguis = 1: 1.

Dorsal chaetotaxy of abdomen as in Figure 10. Abd I–III with 2 irregular rows of dorsal setae, 1 sensorial seta on P5, except Abd V with p3 as sensorial seta. Number of axial setae from Abd I to III is 2 + 2: Abd. IV with 3 + 3; Abd. V with a1 and a2, p3 is ss. Abd VI with 2 rows of setae, a1-3, p1 modified as spine, p 2-3 normal setae. Two small anal spines, as short as their tubercle.

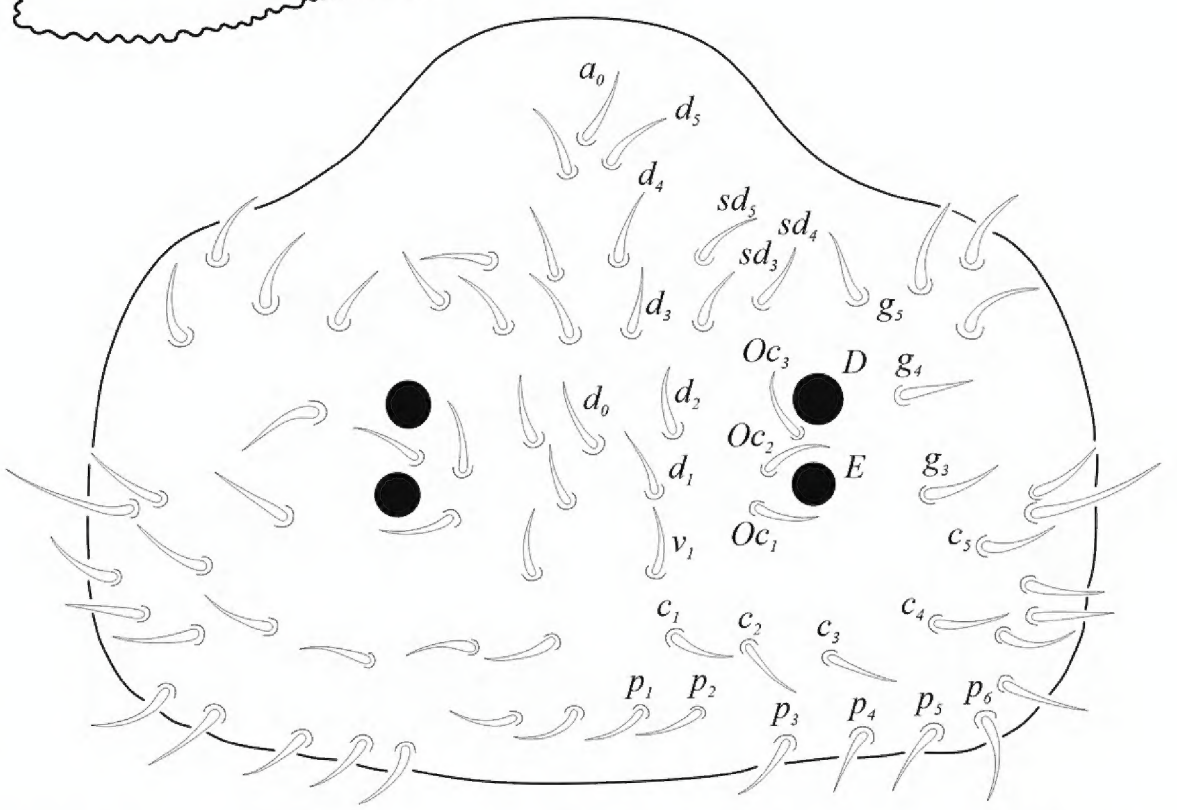
Ventral chaetotaxy. Thoracic sternites and Abd I without setae. Ventral tube with 4 + 4 setae. Abd II with 9 – 12 setae, one of them (p3) very long; Abd III with 6 setae, p3 slightly longer than others. Abd IV dorsolateral with 5 setae, one of them very long (Figure 10). Retinaculum with 3 + 3 teeth, without seta on corpus (Figure 10). Furcula well developed. Manubrium with 3 pairs of setae of same length. Dens dorsally with moderate granulation and with 2 subequal setae, with a smooth elongated area on anterior part of dens. Mucro more than the half-length of dens, long and narrow with one small outer lamella, apex curved and more sclerotized (Figure 11). (Ratio Manubrium: dens; mucro = 1:0.8; 0.5). Mucro better delimited on anterior part by a clear notch (Figure 12). Genital plate of female with 3+3 pregenital, 10–13 circumgenital



5



7

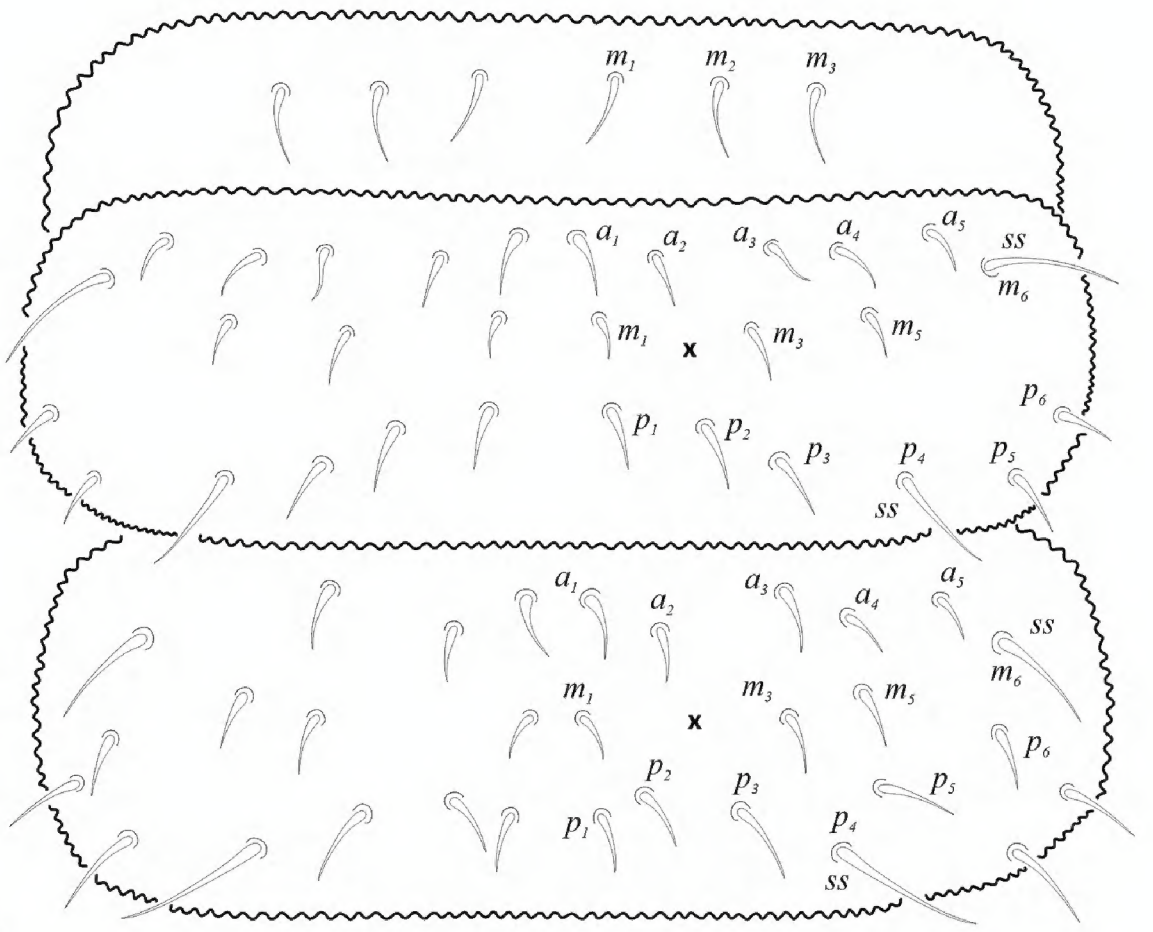


6

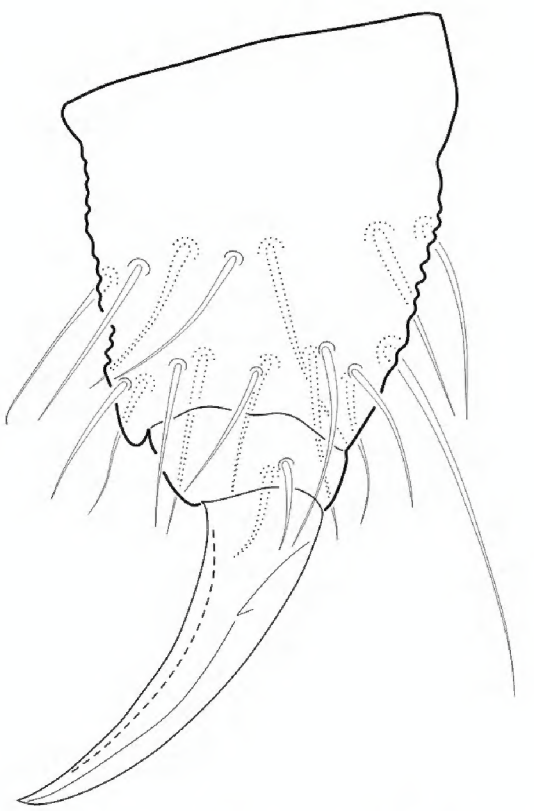
Figures 5–7. *Acheroxenylla lipsae* sp. nov. **5** ant IV dorsal view **6** head chaetotaxy **7** Tita I.

and 1 + 1 eugenital setae. Genital plate of male with 3 + 3 pregenital, 44 circumgenital and 4 + 4 eugenital setae. Each anal valve with 13 regular and 1 hr setae.

Variation. Some asymmetries on body chaetotaxy were observed. Several specimens have setae somehow displaced, giving the appearance of asymmetries. One case



8



9

Figures 8, 9. *Acheroxenylla lipsae* sp. nov. **8** dorsal chaetotaxy of Th. I – III **9** Tita III.

of supernumerary setae on left side of abdominal segment III was observed on one paratype, where there were 3 setae "p4", giving the appearance of sensorial seta to be on position "p7".

Etymology. This species is dedicated to Josiane Lips, for her contribution to the knowledge of cave fauna from Perú, Mexico and many other places.

Discussion. This new species is the largest and most pigmented member of this genus. The main differences of *Acheroxenylla lipsae* sp. nov. and the other species

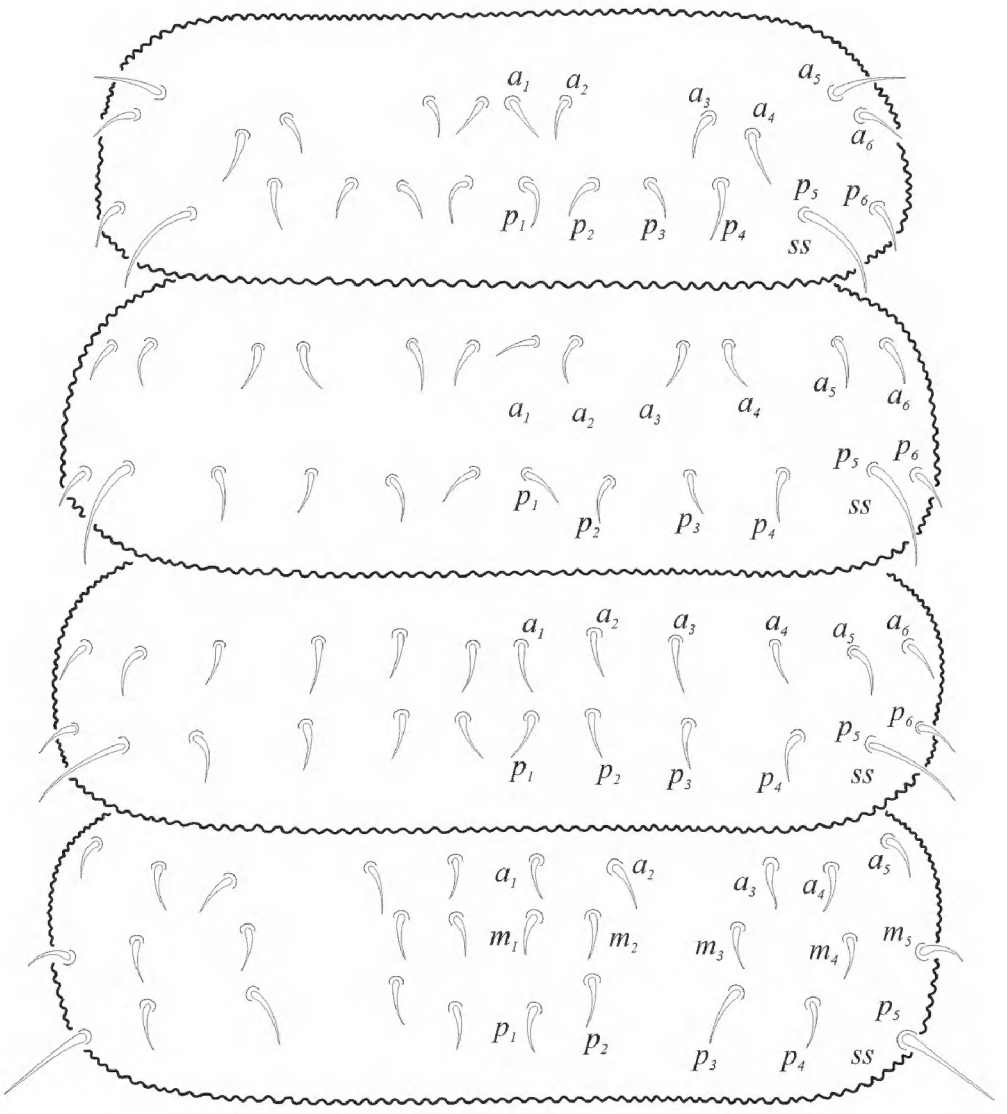
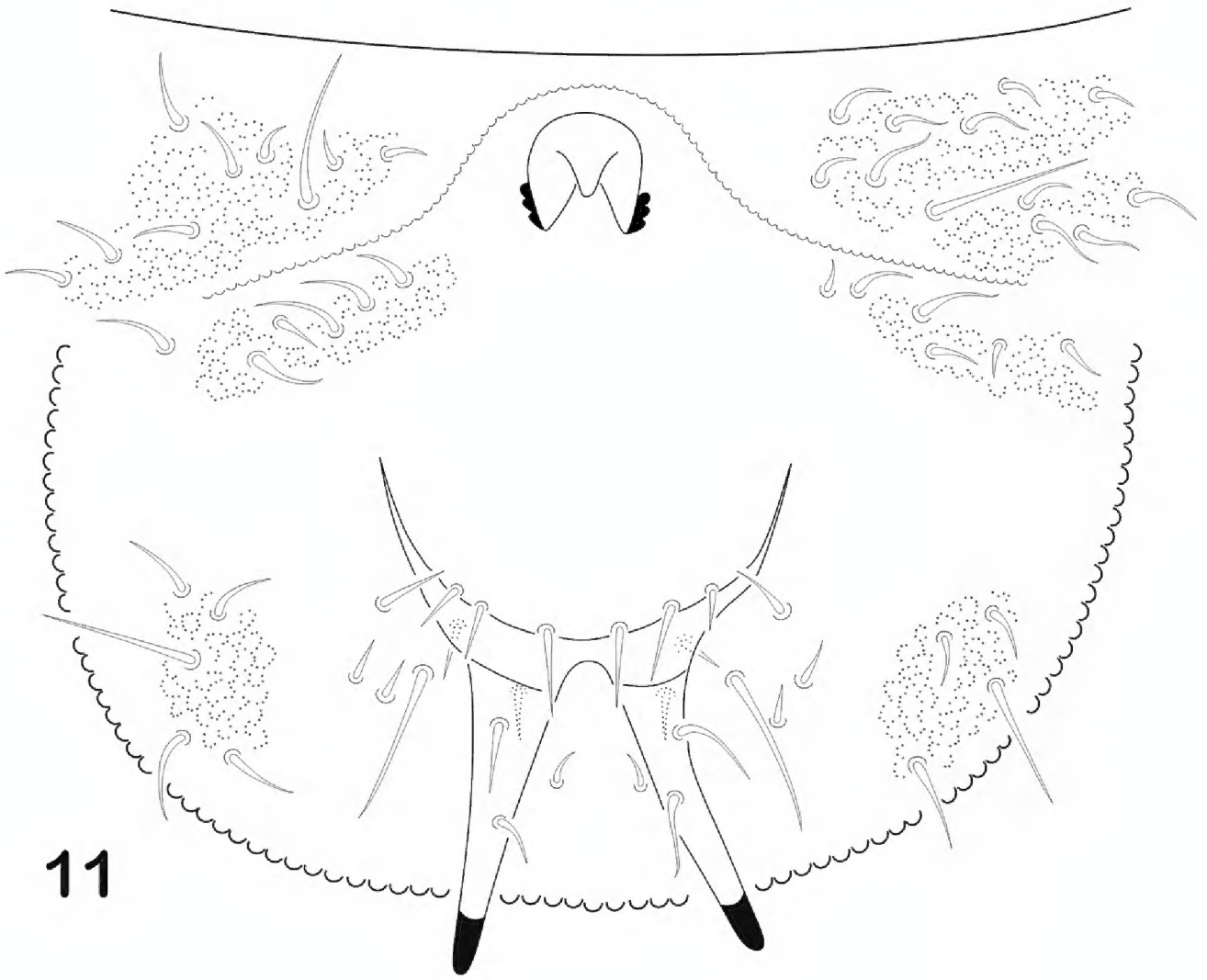
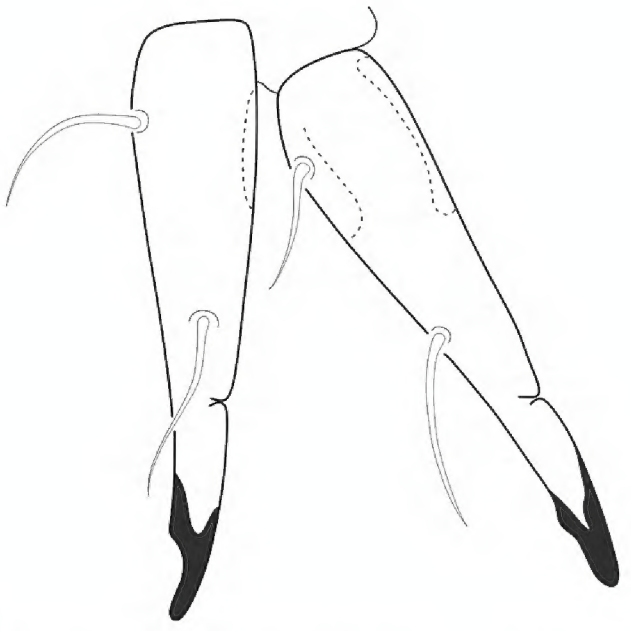


Figure 10. *Acheroxenylla lipsae* sp. nov. Dorsal abdominal chaetotaxy.

is the presence of a well-developed furcula with mucro, long dens and two long dental setae, 3 + 3 manubrial setae and retinaculum with 3 + 3 teeth. *A. furcata* has a reduced furcula, with no manubrial setae, very short dens with one seta each and mucro absent; its retinaculum has only two teeth on each ramus. The type species *A. cretensis* and *A. canariensis* lack completely the furcula and retinaculum. All the species have only two eyes per side; nevertheless, in the new species *A. lipsae* sp. nov., eyes are better developed and closer to each other, and that is why their position seems to be "D" and "E". After the drawings of Ellis (1976), the eyes of





Figures 11, 12. *Acheroxenylla lipsae* sp. nov. 11. Ventral abdominal chaetotaxy from Abd. III to V, with retinaculum and furcula; 12. two mucrodens in lateral position.

A. cretensis are "B" and "E"; as pointed by Ellis (1976): "only 2 + 2 eyes small, widely separated ocelli". Another difference is that *A. cretensis* has only 2 subdorsal cephalic setae, while the new species has 3 pairs, setae sd5, sd4 and sd3, similar to *A. furcata*. There are small differences in the head chaetotaxy, *A. lipsae* sp. nov. has cephalic setae a0, as *A. cretensis*.

About the pigment, *A. furcata* is white with small spots under each of the 2 + 2 or 1 + 1 eyes and sometimes a scattered bluish gray pigment is present all over the body, while *A. lipsae* sp. nov. is more pigmented. Tibiotarsi of *A. furcata* with one apical tenent hair (A1), sometimes weakly clavate, is similar to the new species. The ungues of the Peruvian species is more elongated than in any other species of the genus (ratio tibiotarsus: ungues: 1: 1.0), so this may be a troglomorphic character, and also in the other species tibiotarsus is about twice the length of ungues.

Molecular results. DNA was successfully obtained from three specimens, sequences BCICL008–19 (length 620bp), BCICL009-19 (657bp) and BCICL010 (632bp), which were deposited in the project BCICL of the Barcode of Life Data System (http://www.barcodinglife.org/index.php). Cuticles of two specimens were recovered and mounted in Hoyer's solution which represent the vouchers and are kept at the author's institution as type material.

Description of the cave. The type locality is Cueva de Samuel. Collecting was done 200 m from the entrance on Guácharo guano, where was the new species found. It is an active cave with water flowing from the cave. The air temperature was 15 °C. Its entrance is about 1,720 m a.s.l. In the first part of the cave there is a gallery with a colony of oil birds (Guácharos, *Steatornis caripensis* Humboldt, 1817). 500 m deep in the cave there is a big room with many big stalagmites, named Chachapoyas room. There are two small waterfalls, a small at 800 m from entrance and more far another of 10 m. One of the tunnels finishes in a well of more than 40 m.

Other Collembola in the area. There were 20 springtails found in the region of Rioja. In two caves only one species was found in each: Cueva del Lobo Perdido (*Pseudosinella* sp.) and Tragadero de Bellavista (*Cyphoderus* sp.). Two other caves had three Collembola: Piedra Brillante (*Trogolaphysa* sp., *Pseudosinella* sp., *Pararrhopalites*) and Cueva de los Loros (*Pseudosinella* sp., *Dicranocentrus* sp., *Trogolaphysa* sp.). In Cueva Palestina there were four species: (*Pseudosinella* sp., *Folsomia* sp., *Folsomiella caeca* (Folsom, 1927), *Folsomides troglobius* (Rapoport & Maño, 1969) while Cueva de Samuel was the most diverse with a new species of *Acheroxenylla*, and also specimens of *Folsomina* sp., *Pseudosinella* sp., *Trogolaphysa* sp., *Cyphoderus* sp., *Isotomurus* sp., *Pararrhopalites ecuadorensis* Bretfeld et Trinklein, 2000.

Folsomiella caeca (Folsom, 1927) was described from limestone caves in bat dung at Panama. Later it was found at Ecuador in guano from several caves by Najt and Thibaud (1987). As it also was collected by one of them in Venezuela and Peru, they have considered this species to edaphic - troglofile. *Folsomides troglobius* (Rapoport et Maño, 1969) was originally described from one cave close to Araira, and Cueva del Guácharo in the state of Miranda, Venezuela. Later was cited by Najt and Thibaud (1987) from the cave of Barberanes in Ecuador. This is the first time that both species has been cited from Cueva Palestina in Perú.

In Cueva Samuel, besides the new species, there were other six Collembola found in different samples. Among them, *Pararrhopalites ecuadorensis* Bretfeld et Trinklein, 2000 was described from one cave from Otonga (Cotopaxi), Ecuador and now is found for the first time from Peru.

Acknowledgments

The molecular part of this contribution was done thanks to the project "Application of metabarcoding tools to long-term monitoring of soil fauna" (Yves Basset & Héctor Barrios), funded by SENACYT FID16-070. Dr. Diana Silva Dávila, Dept. Entomology; Museo de Historia Natural, Universidad Mayor de San Marcos, Perú kindly lend the cave material collected by Josiane Lips for study. Yony Callohuari (Museo de Entomología Klaus Raven Büller – Universidad Nacional Agraria La Molina) made the slides. Blanca Mejía mounted the cuticles recovered from the sequence's extraction. Jair Paéz made some drawings under the microscope and prepared the final drawing plates (Fac. Ciencias, UNAM). The Franco-Peruvian Scientific Expedition "Cerro Blanco 2017" lead this study, Dr Jean-Loup Guyot, Dr Xavier Robert, of the Research Institute for Development (IRD), and James Apaéstegui, of the Instituto Geofísico from Perú (IGP). This speleological expedition was organized and supported by Spéléologique Groupe of Bagnols-Marcoule (Gard, France), the Vulcain Caving Club (Lyon, France) and the Espeleo Club Andino (Lima, Peru), the IRD and the IGP. Dr. Frans Janssens reviewed the manuscript and gave important comments to improve it. Larry La Rose (Tres Cruces, N. M. USA) reviewed the final manuscript.

References

Bellinger PF, Christiansen KA, Janssens F (1996–2019) Checklist of the Collembola of the World. http://www.collembola.org

Bocanegra Buitrón TR (2014) Lista Taxonómica comentada de los Collembola de Perú con aportes a su distribución geográfica. Universidad Nacional Federico Villarreal, Perú. Facultad de Ciencias Naturales y Matemática. Escuela profesional de Biología. Tesis de Licenciatura, 78 pp.

Ellis WN (1976) Autumn fauna of Collembola from Central Crete. Tijdschrift voor Entomologie, 119(8): 221–326.

Fjellberg A (1992) Collembola of the Canary Islands. 1. Introduction and survey of the family Hypogastruridae. Entomologica Scandinavica 22(4): 437–456. https://doi.org/10.1163/187631291X00246

Najt J, Thibaud J-M (1987) Collemboles (Insecta) de l'Equteur. 1. Hypogastruridae, Neanuridae et Isotomidae. Bulletin du Museum National d'histore Naturelle, Section A Zoologie Biologie et Ecologie Animales 9(1): 201–209.

Thibaud J-M, Schulz H-J, da Gama Assalino MM (2004) Synopses on Palaearctic Collembola, Volume 4. Hypogastruridae. Abhandlungen und Berichte des Naturkundemuseums Görlitz 75(2): 1–287.

Ratnasingham S, Hebert PD (2013) A DNA-based registry for all animal species: the Barcode Index Number (BIN) system. PloS ONE 8(8): e66213. https://doi.org/10.1371/journal.pone.0066213